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THE SIGNIFICANCE OF RESPIRATORY SYMPTOMS AND THE DIAGNOSIS OF CHRONIC BRONCHITIS IN A WORKING POPULATION

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The difficulty of defining "chronic bronchitis" has been referred to in many recent publications (Higgins *et al.*, 1956; Stuart-Harris and Hanley, 1957; Oswald, 1958). One essential feature of the disease, upon which Scadding (1952) based his definition, is "chronic or recurrent cough with expectoration," but there is no agreement upon where the line should be drawn between "the earliest phase of the disease and health" (*British Medical Journal*, 1959); nor has it been shown that any such line can be drawn by simple symptomatic inquiry, without the gross observer variation first described by Cochrane *et al.* (1951).

We have investigated this diagnostic problem by asking working men and women in London a number of questions about cough, expectoration, and other symptoms. The same subjects were asked these questions on two occasions, and the validity and significance of their replies were tested by comparison with measurements of sputum volume, ventilatory capacity, and sickness absence rates. Fairbairn *et al.* (1959) discuss elsewhere the variation that was found between the answers obtained by the three doctors and three nurses who asked the questions, and they suggest means of reducing this variation. The errors found were not so great as to preclude the use of the method for survey purposes.

In this paper we are concerned with the prevalence of symptoms in the men and women we studied and with the relationship of these symptoms to one another and to the results of the more objective tests. We propose a definition of chronic bronchitis and suggest simple combinations of questions and tests by which the disease may be diagnosed.

Methods

Fairbairn *et al.* describe the selection of subjects and the questionnaire that was used. The parts of the questionnaire referred to in the present paper are given in the Appendix. The men, aged 40–59, were postmen

attached to the East Central Divisional Office of the General Post Office in the City of London. The women, also aged 40–59, were engaged in sorting documents in the Post Office Savings Branch of the General Post Office in West London. 192 subjects of each sex were interviewed on the first occasion, and 144 of these were interviewed on the second occasion. Elmes *et al.* (1959) have described how sputum specimens were collected and examined. These specimens were collected from the men in February, March, and August, and from the women in March and August, and consisted of the sputum brought up in the first hour after rising.

Measurements of the one-second forced expiratory volume (F.E.V.₁) (Gandevia and Hugh-Jones, 1957) were derived from tracings of expirations made on a light spirometer with a paper speed of 2 cm./sec. They were corrected to body temperature and saturation, and, for some purposes, were standardized to age 40 from the regression relationship with age, using those subjects who denied cough, sputum, and breathlessness. The results were multiplied by 35 and expressed as indirect maximum breathing capacity (M.B.C.), since this correction has been widely used in epidemiological surveys in this country, and the normal values of the M.B.C. are more generally known than for those of the F.E.V.₁. The sickness absence records of each subject for the previous three years were inspected, and all absences lasting more than one week with a diagnosis of influenza, bronchial catarrh, and bronchitis were considered to be "chest illnesses." These were recorded for comparison with chest illnesses reported by the subject during this period.

Prevalence of Respiratory Symptoms

Cough and Phlegm.—In recording replies to questions 1–10 on cough and phlegm the interviewers were instructed to record as positive only cough or phlegm which occurred "on most days for at least three months every year." Table 1 shows that about half the men

TABLE I.—Percentage of Positive Answers to Questions at First Interview

Question	Men			Women		
	Aged 40-49	Aged 50-59	All Ages	Aged 40-49	Aged 50-59	All Ages
1 Cough, usually	24	37	30	21	17	19
2 " on rising, winter	42	54	48	27	21	24
3 Cough on rising, summer	26	39	32	18	7.5	12.5
2+4 Cough all day, winter	14.5	20	17	12.5	5	9
2+5 Cough all day, summer	8.5	11.5	10	6.5	3	4.5
6 Phlegm usually	31	47	39	20	18	19
7 " on rising, winter	29	47	38	22	22	22
8 Phlegm on rising, summer	18	32	25	14.5	8.5	11.5
7+9 Phlegm all day, winter	8.5	25	16.5	6.5	4	5
7+10 Phlegm all day, summer	5	13.5	9.5	3	2	2.5
17 Dyspnoea grade 1 (no dyspnoea)	90	64	77	73	68	70
Dyspnoea grade 2	8	20	14	22	26	24
" " 3	2	14	8	4	5	4.5
" " 4 and 5	—	2	1	1	1	1
22 Wheeze occasionally	47	50	48.5	49	45	47
23 Wheeze most days or nights	10.5	20	15	8.5	6.5	7.5
29 Colds usually go to chest	31	37	34	36	40	38
31 Chest affected by weather	31	41	36	25	25	25
31+38 Chest affected by weather, with breathlessness	20	28	24	19	21	20
41 Nasal catarrh: winter	37	47	42	35	29	32
42 Nasal catarrh: summer	23	27	25	18	19	18.5
43+43a Chest illnesses*: only 1	25	15	20	29	21	25
Chest illnesses*: 2 or more	13	25	19	23	33	28

* Excluding illnesses stated to be less than 1 week in duration.

and a quarter of the women had morning cough; rather fewer admitted to phlegm. As would be expected, cough and production of phlegm was more commonly recorded on rising than during the day and in winter than in summer in both sexes. The prevalence of positive answers to the less specific questions (1 and 6), "Do you usually have cough/phlegm?" (used by Higgins *et al.*, 1956; Higgins, 1957), roughly corresponded to that of "cough on rising in winter and summer" and of "production of phlegm on rising in the winter" respectively. While the prevalence of each grade of symptom was higher in the older than in the younger men, the reverse was true in the women.

Most of the cough and phlegm reported could be regarded as chronic; for only 5% of all subjects with

cough or phlegm said that these symptoms had been present for more than three years (Question 16).

Breathlessness on Exertion.—Subjects were classified into five grades of breathlessness on their replies to questions (17) similar to those described by Fletcher (1952). As with cough and sputum, there was a significantly greater prevalence of breathlessness in the older than in the younger men but no trend with age in the women. The net effect was a similar prevalence in the two sexes, with a slight but not significant excess of grades 3 and over in the men compared with the women.

Other Symptoms.—Nearly half of both the men and women of all ages admitted to occasional wheezing, chiefly with colds. Significantly more men than women admitted to wheezing "most days or nights," and here, too, the prevalence was greater in the older men. There is little sex or age effect in the proportion of subjects who said that colds went to their chests. Rather more men than women said the weather (chiefly fog) affected their chest and that adverse weather caused dyspnoea—again a slight age differential is apparent in the men but not the women. Positive replies to the question "Do you usually have a stuffy nose or catarrh at the back of your nose?" were frequent. This symptom was nearly twice as prevalent in winter as in summer, again with a slightly higher prevalence and an age effect in the men. Chest illnesses were of similar prevalence in the two sexes. The older subjects of both sexes had more frequent illnesses.

In summary, chest symptoms were prevalent in both men and women. The chief difference between the sexes was that for nearly every symptom the prevalence rose with age in the men but not in the women. Only cough and phlegm were significantly more prevalent in the men as a whole than in the women. These differences are discussed below.

Symptoms in Relation to Objective Measures.—Chronic cough and sputum, with recurrent chest illness and breathlessness on exertion, are chief complaints upon which chronic bronchitis is customarily diagnosed, and we have related these symptoms to observations made on the sputum specimens, records of sickness absence from chest diseases, and ventilatory capacity (estimated by indirect M.B.C.).

Phlegm Production

The replies on phlegm production rather than on cough are considered because the former are more relevant to the sputum specimens. The replies to questions on cough and phlegm were closely related. Of 62 men who denied any phlegm at the second

TABLE II.—Relationship Between Answers to Questions about Phlegm Production and Winter Sputum Volumes, Indirect M.B.C. (standardized to age 40) and Other Symptoms. Men: Second Interview

Time at which Phlegm Production Admitted	No. of Men	No. of Sputum Bottles Returned*	Percentage of Bottles, with Sputum Volumes:				Mean Indirect M.B.C. (l./min.)	Symptom Markst (% Possible)
			Nil	<2 ml.	2-6 ml.	>6 ml.		
No phlegm	62	105	75	16	7	2	117	10
On rising only	30	48	23	40	27	10	112	20
During day	16	26	35	38	15.5	11.5	110	26
Part	46	74	27	39	23	11	111	22
On rising and during day	36	68	16	15	36	33	93	52
Winter only	31	54	30	24	31.5	14.5	100.5	32
All year	51	87	17.5	30	27.5	25	107.5	38
"Usually" (question 6)	60	100	16	23	32	29	102	41

* Two possible winter specimens per man.

† One mark for dyspnoea grade 2, wheeze most days, weather affects chest without dyspnoea, 1 chest illness. Two marks for dyspnoea grade 3, weather causes dyspnoea, 2 or more chest illnesses.

interview, only 12 (19%) said they coughed, while of 59 men who denied any cough, only 9 (15%) said they produced phlegm. Five questions about phlegm production were used to grade its severity. The prevalence of positive answers to these questions (Table I) suggests that such a grading might be based either on the time of the day or on the time of the year during which phlegm was produced, or on both. We have tried to see which is the more valid by the relationship of positive answers to the volume of sputum and the indirect M.B.C. We deal with the answers given by the men (because of their greater frequency of positive replies) at the second interview (because on the first occasion questions about cough and phlegm during the day were asked only if they had occurred on rising, so that subjects coughing or expectorating only during the day were missed). In Table II the men are grouped according to the time of day and year at which they said they produced phlegm.

The questions referred to the usual habit "for most days for at least three months each year." A subject who "usually" produced phlegm might naturally fail to do so on the two particular days when the specimens were collected. Conversely, a subject "usually" free from phlegm might have a short period of productive cough. Thus it is not surprising that 25% of those who denied phlegm produced sputum, mostly in small amounts. 23% of the subjects who said they had morning phlegm returned empty bottles. In a few of these subjects there is indirect evidence that this may have been due to failure to co-operate (Elmes *et al.*, 1959).

The distribution of winter sputum volumes is very significantly different ($P < 0.001$) in three groups of men: those who denied phlegm, those who admitted to it for only part of the day (only on rising or only later on), and those who admitted to it throughout the day. There is, however, a negligible difference ($P = 0.7$) between those who admitted to phlegm only on rising and those who admitted to it only later in the day. Similarly, there is no significant difference between those who admitted to phlegm only in the winter and those who admitted to it throughout the year ($P = 0.2$).

It appears, therefore, that subjects who denied phlegm, those who noticed it on rising or later in the day only, and those who noticed it both on rising and throughout the day are three groups characterized by progressively greater sputum volumes in the first hour after rising. This presumably indicates increasing degrees of bronchial hypersecretion. Classification of our subjects according to the time of year or time of day when the phlegm was experienced gives no additional information.

The three groups of subjects also show a downward trend in the mean values of the M.B.C. The mean value of those denying phlegm (117) is slightly but not significantly higher than those with phlegm for part of the day only (111), but the mean of each of these groups is significantly higher than the mean of those with phlegm throughout the day (93). The mean values of those with phlegm in the winter only (100.5) and with phlegm throughout the year (107.5) do not differ significantly.

Although not an objective criterion, the frequency of other symptoms assessed on an arbitrary system of marking (shown in the last column of Table II) also supports this threefold classification. The differences

between these three classes of men according to the three criteria we have chosen are illustrated in Fig. 1.

The apparent similarity of those with winter and those with perennial phlegm is surprising, since it is often thought that a winter cough represents an earlier stage of chronic bronchitis than a perennial cough. The explanation appears to be that recollection of summer phlegm production was inaccurate in our

FIG. 1.—Relationships between time of phlegm production and volume of winter sputum, indirect M.B.C., and other symptoms.

subjects, who were questioned during the winter. It is shown in Table III that 40% of those who said they produced phlegm only in winter produced specimens of the same mean volume in summer. The proportion of men who produced specimens of sputum in summer was only just significantly less in those who denied than in those who admitted to summer phlegm. Thus questions on seasonal changes in phlegm production do not produce answers reliable enough to be worth asking.

When the subjects are divided into three groups either by the questions or by measurement of sputum volumes (Table IV) there is a highly significant correlation

TABLE III.—Replies to Questions on Phlegm Production in Winter and Summer Compared with Sputum Specimens. Men and Women Combined

Replies to Questions on Phlegm	Percentage of Returned Bottles Containing Sputum		Mean Volume of Sputum (ml.)†	
	Winter*	Summer	Winter*	Summer
Phlegm only in winter ..	69	40	4.1	4.0
„ winter and summer	72	64	5.0	3.8

* February specimen for men, March for women.

† Excluding empty bottles.

TABLE IV.—Relationship Between Grades of Expectoration Based on Answers to Questions and on Measurements of Winter Sputum Volumes. (Men: Second Interview. Two Winter Specimens Combined. Women: First Interview)

Sex	Answers to Phlegm Questions	Sputum Volume			Total
		Nil	< 2 ml.	2 ml. +	
Men	No phlegm ..	79	17	9	105
	Phlegm part of day	20	29	25	74
	„ all day ..	11	10	46	67
	Total ..	110	56	80	246
Women	No phlegm ..	124	14	5	143
	Phlegm part of day	19	11	9	39
	„ all day ..	3	6	1	10
	Total ..	146	31	15	192

($P < 0.001$) between the two methods in both sexes, but the sputum volumes place rather more subjects in the most abnormal group. Table V shows that the two methods have similar repeatability, placing 76% and 72% of the subjects respectively into the same groups on the two occasions.

TABLE V.—*Repeatability of Grading of Expectoration by Answers to Questions and by Measuring Sputum Volumes: Men*

Answers at First Interview	Answers at Second Interview			Total
	No Phlegm	Phlegm Part of Day	Phlegm All Day	
No phlegm ..	58	13	3	74
Phlegm part of day	4	15	8	27
„ all day ..	—	2	25	27
Total ..	62	30	36	128*
Volume of Sputum in February	Volume of Sputum in March			Total
	Nil	< 2 ml.	2 ml. +	
Nil ..	46	10	5	61
< 2 ml. ..	6	18	8	32
2 ml. + ..	4	6	35	45
Total ..	56	34	48	138†

* Omitting 16 men who admitted to phlegm only later in the day since these were missed at first interview (see text).

† 54 men failed to return sputum bottles on one or other occasion.

We have assumed that the phlegm to which our subjects admitted and the sputum they produced came from their bronchi and not from their sinuses. In the questions about phlegm the interviewers were instructed to emphasize the words “from your chest,” and the words “not from the back of your nose” were inserted to attempt to exclude nasal secretions. In both men and women the frequency of winter nasal catarrh (question 41) was twice as great in those who said they produced phlegm as in those who denied it, and it was more frequent in those with greater volumes of sputum than in those with smaller volumes. This association of phlegm production with nasal catarrh was similar in degree to its association with other symptoms such as dyspnoea, colds going to the chest, and chest illnesses. It seems more likely that there is a real association between nasal and bronchial catarrh than that the two were confused. We believe that our questions and our instructions concerning the sputum specimens were such that we were concerned predominantly with bronchial and not nasal secretions.

We conclude that asking questions and collecting sputum provide two similar, reasonably repeatable methods of grading the amount of expectoration. Sputum collection is more objective, but demands co-operation in a procedure which is troublesome and may be distasteful. Moreover, it is liable to error in collection and to the effects of variations in sputum volume during a transient chest infection. The questions are perhaps more relevant to the chronic condition in which we are interested, and are easy to ask; but they are liable to the observer variation described by Fairbairn *et al.* (1959), which renders uncertain comparisons between surveys carried out by different observers (see Table XII).

There is a significant but not very close association between the replies to questions about the colour of the phlegm and purulence of sputum specimens. 50% of the sputum specimens were mucopurulent in those

who said their phlegm was “always white, grey, or black,” but 80% in those who said it was sometimes or always yellow.

Chest Illnesses

Elmes *et al.* (1957) found that out-patients with chronic bronchitis tended to exaggerate the number and duration of past sickness absences from work owing to chest illness. We therefore compared our subjects' accounts of their chest illnesses with their sickness absence records. In the questionnaire a simple question (43) about chest illnesses which had kept the subjects off work was first asked, and if this was negative a supplementary question (43a) was asked (“not even ‘flu?’”) to stimulate the memory. In Table VI the illnesses remembered as the result of the first question are compared with the sickness absence records.

In the men the correspondence is quite good, but is enhanced by the high proportion with no illnesses. There is only 37% agreement in those who either admitted to or had a record of a chest illness. There is, however, no evidence that answers to questions exaggerated the number of illnesses. The supplementary question elicited 12 more illnesses, the inclusion of

TABLE VI.—*Comparison Between Sickness Absence Records for Chest Illnesses and Illnesses Reported in Answer to Question 43*

No. of Chest Illnesses Reported in Answer to Question	No. of Chest Illnesses from Sickness Absence Records							
	Men				Women			
	None	1 Only	2 or More	Total	None	1 Only	2 or More	Total
None ..	93	14	5	112	56	31	15	102
1 only ..	10	12	4	26	9	9	7	25
2 or more ..	7	7	16	30	10	5	24	39
Total ..	110	33	25	168	75	45	46	166

Correct replies for men = $121/168 = 72\%$.
 women = $89/166 = 54\%$.

which did not affect the agreement with the records. In the women the agreement between recollected and recorded illnesses is less good and there are more of the latter. 26 further illnesses were recalled in answer to the supplementary question, but their inclusion did not improve the agreement. 78% of the women were married, and it is not unlikely that some of their recorded absences were due to domestic cares rather than to actual illness. There was no reduction of mean indirect M.B.C. in those subjects of either sex who reported illnesses only in answer to the extra question, which does not appear to be worth asking.

There was thus no marked tendency to exaggerate or forget past illnesses. Indeed, the correspondence between recollected and recorded illnesses is surprisingly close in view of the difficulty of deciding from the sickness records what should be counted as a chest illness.

Breathlessness and Indirect M.B.C.

Measurements of the indirect M.B.C. were made upon all but one of the men at the second interview, giving 143 readings. Measurements were made on all but five of the women at the first interview, giving 187 readings. The missing readings were due to five subjects who objected to the procedure and to one technical error.

Fig. 2 shows the frequency distribution of the M.B.C. in men and women. There were a few men with greatly impaired ventilatory capacity who produce a skewing of the distribution to the left. If men admitting to phlegm throughout the day are excluded, a relatively normal distribution is obtained. The mean values are then 113.5 for men and 97 for women, with coefficients of variation of 18.6 and 14.2 respectively. There are only two women but 11 men with M.B.C.s more than two standard deviations below this mean; 10 of these men admitted to phlegm throughout the day, and one to phlegm on rising only, but the two women denied any phlegm.

The indirect M.B.C. correlates poorly with the answers to questions on dyspnoea (Table VII). There was only a slight depression of mean M.B.C. in association with dyspnoea in the men and none at all in the women. As the test measures only reduction in ventilatory capacity and has no relation to other disturbances of pulmonary or cardiac function that may cause dyspnoea, it is perhaps not surprising that several subjects who said that they had to walk slowly on the level because of dyspnoea (grade 3 or more) had indirect M.B.C.s within 1 S.D. of the mean. It is, however, surprising that, of the 11 men with an indirect M.B.C. more than 2 S.D. below the mean, four denied any dyspnoea (including one man with a value of 22.5 l./min.). Questions about dyspnoea appear to provide a poor indication of impairment of lung function in association with bronchitis. The indirect M.B.C. is reduced by obstruction to bronchial air flow, which is the aspect of lung function that would be expected, on theoretical grounds, to be specifically impaired in bronchitis, and it is an objective, repeatable, and simple test.

Other Symptoms and Indirect M.B.C.

A significant depression of M.B.C. occurs in men who admitted to cough or phlegm throughout the day, to wheeze most days and nights, to adverse weather causing dyspnoea, to having had two or more chest illnesses or one or more illnesses with increased phlegm production. The depression of M.B.C. is in each case largely due to the same 11 men, mentioned above, 10 of whom had three or more of these severer symptoms. If these men are excluded, the mean M.B.C. of the remainder is less markedly yet still consistently depressed in each of these symptom categories.

Fig. 2.—Distribution of age-standardized indirect M.B.C. (l./min.).

TABLE VII.—Relationship Between Age-standardized M.B.C. and Various Symptoms; Men and Women. First Questionary

Symptom Group		Men				Women	
		No.	Mean Indirect M.B.C. (l./min.)		No.	Mean Indirect M.B.C. (l./min.)	
			All Cases	Excluding 11 Low Values			
			No.	Mean			
Cough*	None ..	58	117	58	117	136	98
	On waking or later in day ..	54	112	52	114	33	94
	On waking and later in day ..	31	92	22	104	18	96.5
Phlegm*	None ..	61	117	61	117	138	97.5
	On waking or later in day ..	46	110	45	111	38	97
	On waking and later in day ..	36	93	26	108	11	90
Breathless- ness	Grade 1 (none)	108	113	104	115	131	97.5
	.. 2	21	101	17	106	45	94
	.. 3 or more	14	97	11	109	11	96
Wheezing	None ..	49	114	48	116	84	98
	Occasional ..	73	110	68	113	88	97
	Most days/nights	21	97	16	112	14	88
Effects of weather on chest	None ..	74	117	74	117	110	99
	Affected without dyspnoea ..	31	110	30	112	36	94
	Affected with dyspnoea ..	38	95	28	108	41	95
Chest ill- nesses in past 3 years lasting more than 1 week	None ..	83	117	83	117	86	98
	One only ..	34	105	30	113	48	98
	Two or more ..	26	91	19	104	53	96
	One or more without in- creased phlegm ..	27	110	24	117	41	96
	One or more with increased phlegm ..	33	91	25	102	60	97

* Answers at second interview for men.

There is very little depression of M.B.C. in men with only occasional wheezing, with susceptibility to adverse weather which does not result in dyspnoea, with only one chest illness, or with any number of illnesses unassociated with increased phlegm production.

The women, on the other hand, show no significant reduction of M.B.C. in association with any of the symptoms.

Symptoms and Smoking Habits

It was shown in Table I that, of all the symptoms, only cough and sputum were significantly commoner in the men than in the women. This difference might be due to differences in smoking habits, for, as Table VIII shows, the men were heavier smokers than the women. The prevalence of cough and sputum increases significantly with increasing tobacco consumption in both sexes (Table IX). Among the heavier smokers (15 or more grammes of tobacco daily) there are no significant differences between the prevalences in the two sexes. Among the non-smokers and light smokers the prevalence of cough and phlegm is higher in the men than in the women, though the differences are only just significant. Of the non-smokers and light smokers, significantly more of the men than of the women had smoked heavily in the past; but among these former heavier smokers the prevalence of cough and phlegm

TABLE VIII.—*Number of Subjects with Different Smoking Habits*

Present Smoking Habits	Men			Women		
	Aged 40-49	Aged 50-59	All Ages	Aged 40-49	Aged 50-59	All Ages
Non-smokers	13	13	26	49	50	99
Never smoked	6	4	10	43	43	86
Smokers:						
1-14 g. a day	60	54	114	34	37	71
15-24 " " " " ..	20	22	42	9	7	16
Over 25 g. and more a day ..	3	7	10	4	2	6
Total	96	96	192	96	96	192

1 cigarette = 1 g. of tobacco.

was no greater than in those who had always been light smokers. The rather higher prevalence of cough in the younger compared with the older women does not appear to be due to differences in smoking habits; for the proportions of heavy, light, and non-smokers in the two age groups were almost identical (Table VIII).

Although the numbers of men who had never smoked was small, their mean M.B.C. is significantly higher than that of the ex-smokers or smokers (Table X). The differences between ex-smokers, lighter, and heavier smokers are not significant. One non-smoker had a history of bronchiectasis, and it was this man who was dyspnoeic and had had more than two recent chest illnesses. Apart from this man the non-smokers are almost asymptomatic (Table X). There are otherwise no significant differences in prevalence of symptoms in the different smoking groups in either sex, although dyspnoea grade 3, persistent wheezing (in women), and chest illnesses (in men) appear to be rather more frequent in the heavier smokers. Our findings are similar to those of Higgins (1959), but different from those of Oswald and Medvei (1955), who found a similar prevalence of bronchitis in male and female civil servants with similar smoking habits. The sex contrasts we have found may be associated with the differences

of occupation between our men and women. The greater frequency of cough and phlegm in the men with the smaller tobacco consumption compared with the women might, for example, be due to their exposure on their rounds to London's polluted air.

Comparison With Other Surveys

Comparisons between the prevalence of respiratory symptoms that we observed and the prevalence reported by other authors are difficult because of the effects of technique and definitions. It would be most interesting to know whether our subjects had more or less "chronic bronchitis" than was found by Pemberton (1956) in rural, urban, and coal-mining populations in America. Pemberton defined chronic bronchitis as "chronic

TABLE XI.—*Comparison with Prevalence of Cough and Sputum Reported by Pemberton (1956) in Males in U.S.A. Aged 50-59*

Population	No.	Percentage with "Chronic Bronchitis"		
Pemberton (1956) (U.S.A.):				
Coal-workers	108		29	
Urban dwellers	68		15	
Rural " "	110		12	
Present study:		Type 1*	Type 2†	Type 3‡
Postmen (London) ..	96	39	16.5	12.5

* Cough and sputum at least on rising in the winter.
† Cough and sputum throughout the day in the winter.
‡ Same + "colds usually go to the chest."

cough and sputum," but introduced other considerations in doubtful cases such as the occurrence of chest illnesses and whether or not colds went to the subjects' chests. He also excluded cough apparently due to smoking. The introduction of such qualifications to varying degrees precludes valid comparisons. Pemberton's findings in men aged 50-59 are shown in Table XI, and are compared with the prevalence of different levels of chronic cough and sputum in our cases. It is seen that, according to the definition of chronic bronchitis used,

TABLE IX.—*Relationship Between Present Smoking Habits and Prevalence of Cough and Sputum*

Present Smoking Habits	No.		Percentage with							
			Cough in Winter				Phlegm in Winter			
	Men	Women	On Rising		All Day		On Rising		All Day	
			Men	Women	Men	Women	Men	Women	Men	Women
Non-smokers	26	99	27	9	11.5	3	23	15	15	1
1-14 g. a day	114	71	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
15 g. or more a day ..	52	22	46	30	16	10	39	23	18	8.5
			(i)	(k)	(l)	(m)	(n)	(o)	(p)	(q)
			64	73	23	32	44	45	19	13.5

Significant differences (χ^2)

a v b: P=0.02-0.1.

g v h: P=0.001.

i v k: P=0.05-0.02.

n v o: P=0.05-0.02.

Insignificant differences (χ^2)

c v d: P=0.1-0.05.

e v f: P=0.5-0.3.

l v m: P=0.3-0.2.

p v q: P=0.3-0.2.

TABLE X.—*Numbers of Subjects Admitting to Various Symptoms (percentages in brackets) and Mean Indirect M.B.C. (standardized to age 40) According to Smoking Habits*

Sex	Smoking Habits	No.	Dyspnoea		Wheezing Most Days or Nights	Dyspnoea in Adverse Weather	One or More Illnesses with Increased Phlegm	Two or More Illnesses with Increased Phlegm	Winter Catarrh	Mean Indirect M.B.C. (l./min.). (No. of Subjects in Brackets)
			Grade 2	Grade 3+						
Men	Never smoked ..	10	—	1 (10)	—	2 (20)	1 (10)	1 (10)	4 (40)	132.8 (8)
	Past smoker ..	16	3 (19)	1 (6)	2 (12.5)	4 (25)	3 (18.5)	1 (6)	6 (37)	106.1 (11)
	Smoker: 1-14 g. a day	114	17 (15)	8 (7)	19 (16.5)	28 (24.5)	20 (17.5)	13 (11.5)	46 (40)	110.9 (87)
	" " 15 g. or more	52	7 (13.5)	7 (13.5)	8 (15.5)	16 (31)	15 (29)	8 (15.5)	25 (48)	104.3 (37)
Women	Never smoked ..	86	23 (27)	4 (4.5)	2 (2.5)	17 (20)	28 (33)	14 (16.5)	25 (29)	99.3 (83)
	Past smoker ..	13	3 (23)	—	—	4 (31)	6 (46)	5 (38)	4 (31)	93.3 (13)
	Smoker: 1-14 g. a day	71	13 (18.5)	4 (5.5)	7 (10)	16 (22.5)	23 (33)	12 (17)	22 (31)	96.9 (70)
	" " 15 g. or more	22	7 (32)	3 (13.5)	5 (22.5)	5 (22.5)	5 (22.5)	2 (9)	11 (50)	96.1 (21)

Note.—The totals in each symptom group do not always tally with Table VII because of the inclusion of those who did not have their M.B.C. measured.

TABLE XII.—*Comparison Between Prevalence of Symptoms and Mean Indirect M.B.C. in Male and Female Post Office Workers aged 50–59 and Random Samples of Men and Women aged 55–64 Reported by Higgins (1957) and Higgins et al. (1959).*

Sex	Population	Age Group	No.	Percentage with							
				Cough and Sputum*	Breathlessness		Bronchitic Chest Illness†		“Chronic Bronchitis”‡	Mean Indirect M.B.C. (l./min.)	Mean Expiratory Peak Flow Rate (l./min.)
					Grade 2 and Over	Grade 3	Only One	More than One			
Male	Vale of Glamorgan ..	55-64	86	25.6	24.4	7.9	11.6	4.7	5.8	89	
	Leigh (Lancs) non-mining	55-64	84	17.9	22.6	7.2	4.8	13.1	10.7	85	
	Staveley (Derby) non-dusty	55-64	81	32.1	33.3	11.1	8.6	12.3	14.8	95	
	London postmen ..	50-59	96	29.2	34.4	14.6	6.3	14.6	15.7	91.4	
Female	Vale of Glamorgan ..	55-64	92	7.2	18.9	2.2	7.6	4.3	4.3		297
	London Post Office ..	50-59	192	11.5	29.8	6.3	11.5	15.7	11.4		325

* Positive to questions 1+6. † Positive to questions 43, 44, and 45. ‡ Positive to questions 6, 43, 44, 45 (at least one week's duration).

the prevalence in our subjects can appear greater than in Pemberton's coal-miners or the same as in his rural population. Comparisons are only justified between surveys in which the same questions have been asked. In the surveys reported by Higgins (1957) and Higgins *et al.* (1959) questions almost identical with some of ours were used.

Table XII shows a comparison between two non-mining groups of men aged 55–64 reported by Higgins and our male subjects aged 50–59. Our men were on the average five years younger than those studied by Higgins. Allowing for the decline of 1.2 l./min./year of age (which was the regression on age in our symptomless men) the mean M.B.C. of our men was almost exactly the same as that of the random sample of men in the town of Leigh, in Lancashire, but it was lower than that of the men in the town of Staveley or in the Vale of Glamorgan. The frequency of chest illnesses was much the same in all three urban groups but was lower in the rural men. Our men showed the highest prevalence of breathlessness, but the prevalence of cough and sputum was similar in all the areas except for a low figure in Leigh. For the women we can compare measurements of peak expiratory flow rate which Higgins made, using Wright's expiratory flowmeter (Wright and McKerrrow, 1959), for we also used this instrument on our subjects. It will be seen that, again allowing for age, our figures are almost identical with his. All the symptoms, however, were more prevalent in our women than in his. In view of the similarity in the objective ventilatory function measurements the differences in symptom prevalence may be partly due to observer variation. The differences in cough and sputum are not accounted for by differences in smoking habits in the men; but our women were much heavier smokers than those in the Vale of Glamorgan, and this may well account for their having more cough and sputum. It is notable that the frequency of chest illnesses was similar in our men and in the urban men in Leigh, but both our men and our women had higher chest illness rates than their counterparts in the Vale of Glamorgan. This may be a true effect of urban residence.

Diagnosis of Chronic Bronchitis

Chronic bronchitis implies chronic inflammation of the bronchi of non-specific aetiology. It does not necessarily imply the presence of infection. The presence of inflammation cannot readily be established in life. The disease must in practice be defined and diagnosed upon the symptomatic consequences of the

inflammation—namely, chronic cough and expectoration (when other causes of these symptoms have been excluded). Ever since Badham (1808) first introduced the word bronchitis to medical literature it has been customary to include dyspnoea together with cough and expectoration as an essential symptom of bronchitis. This custom has been supported recently in monographs on chronic bronchitis by Oswald (1958) and by Stuart-Harris and Hanley (1957). Oswald argues, “clearly there must be some disability to warrant a diagnosis of chronic bronchitis, otherwise anyone having occasional cough and sputum, possibly related to smoking, must be included.” He refers to two types of disability—breathlessness and exacerbations of infection—the presence of either of which justifies the diagnosis. Stuart-Harris and Hanley admit that subjects with persistent cough and sputum but without dyspnoea may be in “the earliest phase” of chronic bronchitis, but prefer not to accept the diagnosis in the absence of breathlessness (which in an epidemiological study they found was highly correlated with recurrent illnesses), because to do so would result in a number of “healthy persons” being diagnosed as having bronchitis.

For the epidemiologist, concerned with aetiology, the “earliest phase” of bronchitis must be of special interest, since those subjects who are already disabled by the disease are beyond the reach of preventive medicine. It was for this reason that both Pemberton (1956) and Ogilvie and Newell (1957) accepted mere cough and sputum as evidence of bronchitis. There are pathological grounds for supposing that hypersecretion of mucus favours bronchiolar infection and that such recurrent infections may play an important part in the development of emphysema (Reid, 1954; Leopold and Gough, 1957; McLean, 1958).

For these reasons it seems to us logical from the point of view of pathogenesis, and essential from the point of view of preventive medicine, to admit to the diagnosis of bronchitis all those who have persistent cough and sputum. It seems to us as illogical to reject the diagnosis of bronchitis in those without associated disability as it would be to reject the diagnosis of hypertension in subjects with a raised blood pressure but without symptoms, or of chronic nephritis in the presence of persistent albuminuria but without uraemia. If this be accepted we must consider how to define chronic bronchitis. The first question is whether a productive cough indicating bronchial hypersecretion is essential, or whether a dry cough alone should be accepted.

Of the 144 men we studied on the second occasion, 12 (8.5%) admitted to cough but denied phlegm. All

but one of these men returned sputum bottles in one or other of the winter collections, and six of these 11 bottles contained sputum. A genuinely unproductive cough thus appeared to have been present in only five men. In these men it occurred only on rising in the morning, and all of them had indirect M.B.C.s at or above the mean of all the men without persistent sputum. In the women, 18 (9.5%) admitted to cough but denied phlegm. Fourteen of these women coughed on rising or later in the day, and only three produced specimens of sputum. None of them had a significant reduction of M.B.C. Thus, an unproductive cough persisting throughout the day was recorded in only four women, and in no case was it associated with impaired ventilatory capacity. Chest illnesses were no more frequent in these subjects than in those without cough or sputum. This conclusion will require confirmation on larger numbers of subjects, but meanwhile it seems reasonable to exclude from the diagnosis of chronic bronchitis subjects who do not produce sputum. There were nine men (6%) and 15 women (8%) who admitted to phlegm but denied cough. This inconsistency is not infrequent in clinical practice and may be attributed to the phlegm being produced without effort; for some people a cough implies a forceful action. Such cases should be included as having bronchitis.

We conclude that for our purposes, and within the framework of our questionnaire, *chronic bronchitis may be defined as "the production of phlegm on most days for at least three months in each year."* We may recognize two grades of chronic bronchitis as shown in Table II and Fig. 1. Grade 1 comprises those who produce phlegm only on rising or only later in the day, and grade 2 comprises those who produce phlegm both on rising and throughout the day.

These grades correspond approximately to those producing more or less than 2 ml. of sputum in the first hour after rising in the winter (Table IV). Those two methods of grading have similar degrees of repeatability (Table V), but the greater objectivity of measurement of sputum volume renders this the method of choice. Questions should also be asked because of their greater validity in relation to a chronic condition. In Great Britain chronic bronchitis is so much more prevalent than any other cause of chronic productive cough that it is not necessary to exclude other causes in epidemiological studies. For clinical purposes it is, of course, essential to do this before diagnosing chronic bronchitis.

Bronchitis with Disability

There are two chief kinds of disability in chronic bronchitis: recurrent chest illnesses and breathlessness. We have already discussed the validity and repeatability of questions concerning chest illnesses, and given our reasons for preferring to use measurements of the indirect M.B.C. to questions about breathlessness for estimating impairment of ventilatory function. We suggest the use of two grades of each of these forms of disability. For illnesses we distinguish, as does Higgins (1957), those with only one and those with two or more chest illnesses in the past three years lasting for at least one week and associated with an increase of phlegm production. We have used this criterion of increased phlegm during the illnesses for three reasons. Firstly, because such an increase is a clinical characteristic of exacerbations of bronchitis. Secondly, because the indirect M.B.C. was significantly reduced

in those with such illnesses but not in those with illnesses unassociated with increased sputum (Table VII). Thirdly, because of 21 chest illnesses occurring in men without bronchitis, 11 (53%) were associated with increased phlegm, while in those with grade 1 bronchitis 13 out of 19 (69%), and in those with grade 2 bronchitis 20 out of 22 (91%), had this association.

We have used two grades of impaired ventilatory capacity, the first comprising those with a standardized indirect M.B.C. lying between one and two standard deviations below the mean of all subjects, excluding those with grade 2 bronchitis, and the second comprising those with a standardized indirect M.B.C. falling more than two standard deviations below this mean. These grades correspond to values of 60–80% and less than 60% of the expected figure for the subject's age. Table XIII shows the highly significant relationship between the grade of bronchitis and these two forms of disability in the men.

TABLE XIII.—*Relationship Between Grade of Bronchitis Based on Answers to Questions and Bronchitic Chest Illnesses and Impairment of Age-standardized Indirect M.B.C. Numbers of Men: Percentages in Brackets*

Symptomatic Grade of Bronchitis	Chest Illnesses			Indirect M.B.C.		
	None	Only One	2 or More	Higher than 1 S.D. Below Mean	1–2 S.D. Below Mean	More than 2 S.D. Below Mean
0	51 (82.5)	7 (11)	4 (6.5)	52 (86)	9 (15)	0
1	34 (74)	5 (11)	7 (15)	36 (78.5)	9 (19.5)	1 (2)
2	17 (47.5)	6 (16.5)	13 (36)	20 (56)	6 (16.5)	10 (27.5)
Total	102 (71)	18 (12.5)	24 (16.5)	108 (76)	24 (16.5)	11 (7.5)
	$\chi^2 = 17.2$ $P < 0.001$			$\chi^2 = 28.5$ $P < 0.001$		

We did not find that any other combinations of questions enabled us to discriminate more accurately between the grades of sputum volume, or between those with and without impaired M.B.C., than did the simple questions about phlegm and illnesses. There was, however, a significant association between bronchitis with disability (either from illnesses or from impaired ventilatory capacity) and the presence of dyspnoea, wheezing on most days and nights, and colds or adverse weather affecting the chest. We therefore suggest that questions on these symptoms should be retained in questionnaires for the study of chronic respiratory disease, since important correlations or differences might emerge. For instance, the effect of weather on the chest in bronchitics might provide a useful contrast between subjects living in different areas with different levels of air pollution.

Bronchitis in Men and Women

Mortality from bronchitis in England and Wales is four times as great in men as in women of the ages with which we were concerned, and clinical experience reveals a similar sex difference in patients attending hospital (Oswald, 1958; Stuart-Harris and Hanley, 1958).

The picture of bronchitis that emerges from our study is different in the two sexes. Cough and sputum, but no other symptoms, were more prevalent in the men; all symptoms showed an age gradient in the men but not in the women, and a significant depression of ventilatory capacity in association with symptoms occurred only in the men. We have seen that

differences in smoking habits do not entirely account for the different prevalence of cough and sputum nor for the lack of age gradient in the women. It is possible that women with disability are less likely than men to stay in employment, so that occupational selection may have been partly responsible, although disability would be less likely to interfere with the sedentary work of the women than that of the men, and Higgins (1957) also found little or no age gradient in prevalence of "chronic bronchitis" (cough and sputum with chest illnesses) in women between the ages of 35 and 64. Exposure of our men to the polluted air of the City of London may be partly responsible for the sex differences that we observed, for Fairbairn and Reid (1958) have shown that postmen exposed to air pollution in their daily rounds have higher sickness absence rates from bronchitis than do civil servants working indoors, and that this difference increases with advancing age. However, the striking lack of impairment of ventilatory function in association with cough and sputum and recurrent chest illnesses in the women does suggest that bronchial hypersecretion and recurrent infection have rather different consequences in the two sexes, and that this difference may be at least partly responsible for the sex differences in disability and mortality from chronic bronchitis.

Summary

192 postmen and 192 female Post Office employees in London age 40-59 were studied by a symptomatic questionnaire, by measurements of sputum volume and of ventilatory capacity, and by inspection of sickness absence records.

The men had more cough and sputum than the women, but the prevalence of other symptoms and of chest illnesses was similar in the two sexes. Symptoms increased with age in the men but not in the women. These differences were only partly attributable to differences in smoking habits.

The severity of phlegm production was graded according to whether or not it occurred throughout the day, and this grading correlated well with the volume of sputum produced in the first hour after waking. Whether or not the phlegm was said to be perennial appeared not to matter. Ventilatory capacity was significantly impaired in the men, but not in the women, who had the higher grade of phlegm production, frequent wheezing, susceptibility to adverse weather, and a history of chest illnesses with an increase of phlegm production.

It is suggested that chronic bronchitis should be diagnosed in subjects with a productive cough not due to other causes, and that it should be graded in severity either according to the persistence of the symptom throughout the day or according to the volume of sputum expectorated. Disability from impairment of ventilatory capacity or recurrent chest illnesses should be regarded as complications, and not as essential features of chronic bronchitis, since it is important to recognize the disease before it has resulted in disability. Only prospective studies can determine the prognosis of the suggested grades of bronchitis in respect of the development of disability.

The disabling form of the disease can be referred to as "chronic bronchitis with ventilatory impairment" and "chronic bronchitis with recurrent exacerbations," and may be graded according to the severity of the impairment and the frequency of exacerbations.

Disability appears to be a less frequent consequence of chronic bronchitis in men than in women.

We thank the Post Office authorities for permitting the investigation, their staff for much assistance, and the Union of Post Office Workers and the Civil Service Clerical Association for their support. We also thank the Health Committee of the London County Council for allowing three of their health visitors to take part in the study, and to Miss Axtens, Mrs. Rutter, and Miss Underwood for their careful work. We are particularly grateful to Dr. P. Hugh-Jones for his insistence that unless we collected sputum specimens he would mistrust our symptomatic inquiry. Finally, we thank all the subjects of our investigation for their ready co-operation. Dr. C. M. Fletcher was in receipt of a grant for expenses from the Medical Research Council.

Extract from Questionnaire Referred to in Text

Question No.

1. Do you usually have a cough ? Yes/No
Do you cough at all when you get up or first thing in the morning :
2. (a) in the winter ? Yes/No
3. (b) in the summer ? Yes/No
Do you go on coughing during the day :
4. (a) in the winter ? Yes/No
5. (b) in the summer ? Yes/No
6. Do you usually bring up phlegm from your chest (not from back of your nose) ? Yes/No
Do you bring up any phlegm at all when you get up first thing in the morning :
7. (a) in the winter ? Yes/No
8. (b) in the summer ? Yes/No
Do you bring it up during the day :
9. (a) in the winter ? Yes/No
10. (b) in the summer ? Yes/No
Is this phlegm :
11. (a) always clear white, grey, or blackish ? ☐
12. (b) occasionally yellow or green, at least in parts ? ☐
13. (c) usually yellow or green ? ☐
How long have you had this morning cough/phlegm in the winter :
14. (a) less than one year ? ☐
15. (b) one to three years ? ☐
16. (c) more than three years ? ☐
17. Breathlessness (average in last winter)
Grade 1. Are you ever troubled by breathlessness except on strenuous exertion ? ☐
Grade 2. (If yes). Are you short of breath when hurrying on the level or walking up a slight hill ? ☐
Grade 3. (If yes). Do you have to walk slower than most people on the level ? Do you have to stop after a mile or so (or after $\frac{1}{2}$ hour) on the level at your own pace ? ☐
Grade 4. (If yes to either). Do you have to stop for breath after walking about 100 yds. (or after a few minutes) on the level ? ☐
Grade 5. (If yes). Are you too breathless to leave the house, or breathless after undressing ? ☐
21. Does your breathing ever sound wheezy or whistling ? Yes/No
22. If yes: (a) occasionally (for example, when you have a cold) ? ☐
23. (b) most days (or nights) ? ☐
When you have a cold in the head, does it go to your chest (i.e., is it followed by increased cough or phlegm) :
28. (a) never or only occasionally ? ☐
29. (b) usually or always ? ☐

31. Does the weather affect your chest ? Yes/No
 31a. (If no, check "not even fog or cold?") Yes/No
 35. Does it make you wheeze ? Yes/No
 38. Does it make you breathless ? Yes/No

Apart from colds, do you usually have a stuffy nose or catarrh at the back of your nose;

41. (a) in the winter ? Yes/No
 42. (b) in the summer ? Yes/No
 43. During the last three years have you had a chest illness which has kept you in bed, off work, or indoors ? Yes/No
 43a. (If no, check "not even 'flu?") Yes/No
 If yes to 43 or 43a:
 44. (a) did you have increased cough with the illness(es) ? Yes/No
 45. (b) did you have increased phlegm with the illness(es) ? Yes/No
 46. (c) did you have only one such illness ? ☐
 47. (d) did you have more than one such illness ? ☐
 48. (e) estimated average duration
 62. Do you smoke ? Yes/No
 63. (If no) Have you ever smoked ? Yes/No
 (Record "No" if less than 1 a day for a year)

(If yes):

Cigarettes a week
 Ounces of tobacco/week (hand-rolled)
 Ounces of tobacco/week (pipe)

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Retirement is largely a twentieth-century problem, the size of which can be gauged by the estimate that there will be about 10 million people of pensionable age in this country by 1970. A study group appointed in 1955 by the National Old People's Welfare Council has recently issued an outline of the ways in which people can prepare themselves to meet the psychological and practical difficulties they will be faced with in their old age (*Preparation for Retirement or Adjustment to Ageing*, National Council for Social Service, price 1s. 6d.).

SECRETION OF BLOOD-GROUP SUBSTANCES IN RHEUMATIC FEVER

A GENETIC REQUIREMENT FOR SUSCEPTIBILITY ?

BY

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In a previous study of rheumatic fever subjects we reported an unduly high incidence of non-secretors of ABH blood-group substances (Glynn *et al.*, 1956). This result was based mainly on findings with a single test in which the readily precipitable Le^a substance present in the saliva of most ABH non-secretors was detected by means of rabbit anti-Le^a precipitating serum. This test gave results in close agreement with red-cell Lewis phenotypes and was positive with most A, B, or AB salivas giving negative agglutination inhibition tests for A and B substances.

In the present work we have used this test and also the "ulex" test for secretion of ABH substances to estimate the frequencies of both ABH non-secretors and Le^a non-secretors in normal schoolchildren. In addition, a number of rheumatic fever cases have been added to the series, including 79 salivas from rheumatic fever cases in New York State, kindly made available for test by Dr. Harrison Wood, Medical Director, Irvington House, Irvington-on-Hudson, N.Y.

Many rheumatic fever salivas previously tested only for Le^a precipitation have now been retested for inhibition of ulex extract (see below).

Materials and Methods

1. Fresh specimens of saliva were obtained from approximately equal numbers of schoolchildren of each sex in the area of Slough, Bucks, whose ages were evenly distributed between 5 and 15 years. Specimens were collected, boiled for 10 minutes within two hours of taking, and stored at 4° C. until tested.

2. *Tests for ABH and Le^a Substances in Saliva.*—(a) ABH secretors were detected by testing saliva for its ability to inhibit the natural agglutinins (lectins) for human group O cells present in extracts of gorse seed (*Ulex europaeus*). The method is described by Boyd and Shapleigh (1954). (b) Le^a substance in the saliva was detected, using rabbit anti-Le^a precipitating serum as previously described. Positive results were obtained only with salivas negative in the gorse-extract test.

Results

Secretor and Lewis Gene Frequencies in Normal Schoolchildren

Table I shows the results of testing 669 healthy children's salivas with ulex extract and with rabbit-anti-Le^a serum. Le^a substance was detected by precipitation in 21% of these, and H substance by